

Status of the SALRO Station: Past, Present and Future

Turki S.M. Al-Saud, Abdallah M. Azzeer, Attieh A. Al-Ghamdi, and John Guilfoyle
Space Research Institute
King Abdulaziz City for Science and Technology
P. O. Box 6086, Riyadh 11442
SAUDI ARABIA
E-mail: talsaud@kacst.edu.sa

Abstract

This paper describes the Saudi Arabian Laser Ranging Observatory (SALRO) activities at the Space Research Institute (SRI) of King Abdulaziz City for Science and Technology (KACST). Results are presented to show improved performance over the last few years.

SALRO has realized its re-commission process, after some interruption, and is now planning to run two operational shifts. Increasing emphasis is placed on regular data productivity to serve the SLR scientific community.

Among other issues, SALRO Long Term Bias Stability and Normal Point productivity are reviewed. Future plans for the improvement of the system are presented.

1. Introduction

SALRO is located in the Solar Village 45 km north west of Riyadh. Figure (1) illustrates the interior layout of the SALRO station, which consists of four sections [1]:

- 5.1 meter dome with 0.75 m Contraves telescope.
- Coude' room which contains the laser system, receiver...etc.
- Control room which contains workstations for operating the system, hand paddle, printers ...etc.
- Facility room that contains MPACS rack, computer rack, control rack, electrical distribution, air conditioning controls...etc.

The SALRO telescope configuration is shared aperture. The laser operates at a wavelength of 532 nm with pulse energy of 100 mJ and generates a pulse-width of 110 ps (FWHM) at 10 Hz. The multi-stop epoch timing is used to measure range time-of-flight with picoseconds accuracy.

Retroreflectors mounted on three permanent calibration piers are used to monitor the stability of the system. The west target located a distance of 190 m from the station, is

normally used for routine system delay calibration before and after each satellite pass. The east and south targets are located 400 m and 800 m respectively from the station. Another building at the site is used to support SALRO operations via a local area network (LAN).

The EDC at Munich, FRG, is used as a source of satellite predictions and repository for observed satellite NP data.

2. SALRO Performance

SALRO was delivered in its final configuration, and accepted by KACST in July 1996. It used a 100 μm Single Photon Avalanche Detector (SPAD) for timing and a MCP for range walk corrections via amplitude measurement. In late 1996 both detectors failed and their replacement MCP detector, combined with staffing problems, caused gradual degradation and the eventual site closure.

Resumption of work on SLR facility started in 2000, and SLR started working fully on Jan 1, 2001. Further improvements have since been made. Among the steps taken to improve performance are the following:

- Installation of a 200 μm compensated SPAD.
- Re-organization of the laser, optical paths etc.
- Enhancement of system safety.
- Installation of various cameras in the telescope aperture and Coude' path.
- Development of facilities and procedures for operations and system maintenance in addition to staff training.
- Establishment of high operational standards for maximizing performance in terms of data productivity and up- time.

The SALRO system delivers sub-15 mm single-shot results on LAGEOS, approaching 10 mm on low-orbit satellites about the time of the final acceptance test (FAT). The replacement MCP detector does not appear to have made a significant improvement to RMS; however, a review of the results during the period when the MCP was installed shows an accepted return-rate about 10% of that regularly achieved with a SPAD. While single-photon sensitivity certainly helps to increase return rate, further speculation on conditions causing the low return rate is pointless at this stage.

Figures (2) and (3) show SALRO data productivity and single-shot RMS, respectively, from 1996 to 2002. Since the restart of operation in 2001 attention was paid to the RMS results,

which were not acceptable in the first 9 months, but have stabilized at the sub-15mm once more.

An example of improvement in SALRO performance in the last two years can be seen in Figure (4) that shows the number of passes for high orbit satellites (GLONASS, GPS, and ETALON) from 1996 to 2002. The year 2002 indicates more than 300 measurements for high orbit satellites. No measurements were taken in year 1998 and 1999.

Most improvements in RMS and ranging stability have been realized by work centered on the AOM mode locker – mechanical mounting of the crystal (and therefore precise, repeatable adjustability), the 70 MHz drive source and Active/Active electronics.

Stabilizing the temperature of the controlled electronics environment in the system has also shown a significant gain.

Seven mirrors were eliminated from transmit side by reorganizing the layout on the laser table and first beam expander. The re- organization was undertaken because of burn damage to many components and lack of appropriate spares at the time, an additional benefit being some increase in the transmit efficiency.

Resurvey of the site is currently under way.

The last major area to be addressed is the causes of systematic errors. Since the laser repetition rate is varied on a pass-by-pass basis, in the case of high-orbit targets within the pass, the start diode amplitude varies with different repetition rates, which may introduce walk affects in the discriminator and contaminate the results.

Figure (5) shows the schematic diagram of the safety system connection. The primary purpose of the safety system is to reduce or eliminate the possibility of inadvertent damage to sensitive detectors and electronics.

Long Term Bias Stability performance for SLR stations from October 2001 to September 2002 is shown in Figure (6) [2]. Site survey and other works are underway to eliminate or at least minimize various sources of errors in SALRO measurements.

Total normal points and minutes of data performance for SLR stations from October 2001 to September 2002 are shown in Figure (7) [2]. The figures indicate an incremental improvement in the position of SALRO relative to other stations.

These results represent efforts made toward improving measures of site productivity such as the following:

- Number of passes observed.
- Number of range normal-points created.
- Minutes of tracking.

The communication system is to be improved in order to facilitate rapid transfer and exchange of measurement related data.

3. Future Outlook

There are several steps to be taken to further improve the performance of SALRO and its utilization. These steps include:

- Full day operation.
- Radar surveillance.
- Sun Shielding for Telescope and Mount structure.
- Orbit Processing System.
- Joint Scientific Research.

An Orbit Processing System is to be installed for orbit analysis in the data processing center at the Solar Village. The analysis center can process SLR and GPS data to produce accurate orbits, station coordinates, baselines, and deformation estimates. The system consists of two PCs with LAN type 10/100, and EOS GPS/SLR Win NT orbit processing software, including: Microsoft NT user interface for orbit software, full license Microcosm orbit processing engine, and full software integration and testing on computer hardware. The orbit processing system will be used for both SLR and GPS data. With the SALRO data set increasing, it is now possible to utilize it for domestic research purposes.

Ambient temperatures at the peak of summer exceed 45°C, which is the absolute limit set by Contraves for operating the telescope. These extreme temperatures occur for an hour or two each day for a couple of months per year. A much greater problem is the effect of directed sunlight on the telescope structure, which causes severe pointing distortions. It is common for temperatures to exceed 50°C at the telescope tube. Apart from the thermal distortion of the telescope/mount structure, setting the telescope secondary focus is a challenge because there is no way to calibrate the focus at those temperatures (the extreme temperatures do not occur when stars are visible). To overcome some of the problems, consideration is given to installation of sun shielding for the telescope tube and pillow blocks.

Planning is underway to install an active aircraft detection system. Mount observers are useful for aircraft safety, but not infallible, and air traffic in the Riyadh region is increasing all the time. To achieve more reliable aircraft detection, and therefore free up staff members from mount observing duties, plans are made to introduce a dedicated radar surveillance system.

The aim is to elevate SALRO operations and productivity to be one of the most accurate, productive and reliable stations in the world. The progress achieved so far provides a sound basis to achieve that aim.

An important objective is to maximize the scientific utilization of the SLR data. This can be realized through joint international scientific research in the fields that relate to SLR. Among the topics of interest are:

- The landmass – subsidence, gravity etc.
- Orbital mechanics.
- Relativity.
- Earth rotation.
- Other related sciences.

4. Conclusion

The SALRO is finally realizing its potential, with two years of continuous operations. Performance has been improving and the location proved to be a good choice for SLR measurement. The importance of SALRO to the international scientific community is recognized. Plans call for improving all aspects effecting performance parameters, including adequate staffing for full day operation. More attention and effort will be directed towards enhancing data utilization through joint international scientific research in this field.

5. References

- [1]. Al-Ghamdi, A. A, “Report on Saudi Arabian Laser Ranging Observatory (SALRO)”, in *proceeding of the 10th International Workshop on Laser Ranging Instrumentation*, pp. 120-134, Shanghai, China, Nov. 11-15, 1996.
- [2]. http://ilrs.gsfc.nasa.gov/stations/performance_statistics/perf_2002q3.html

FIGURES

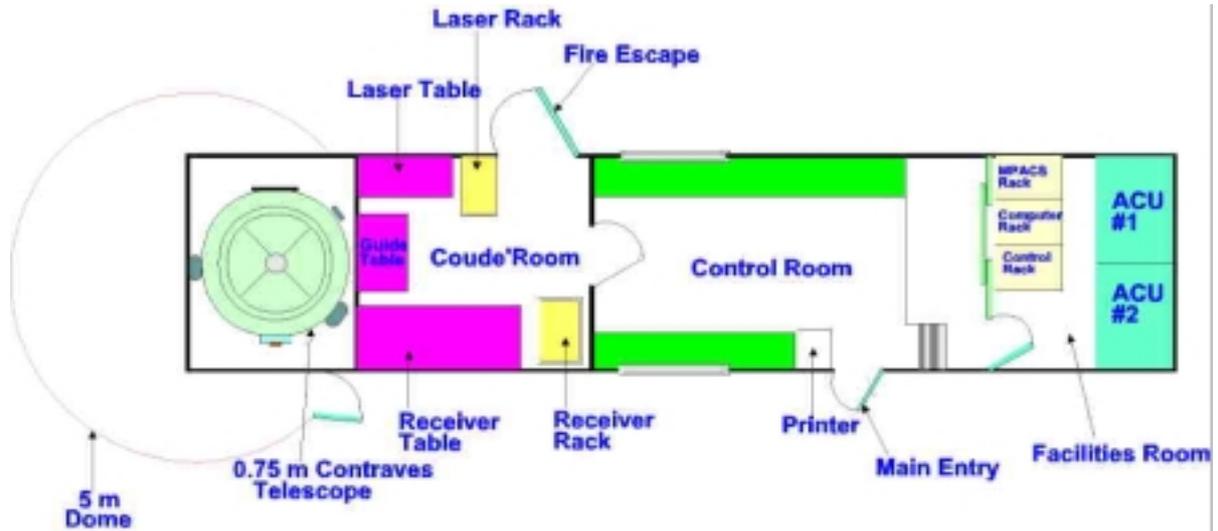


Figure 1: Schematic diagram of SALRO station

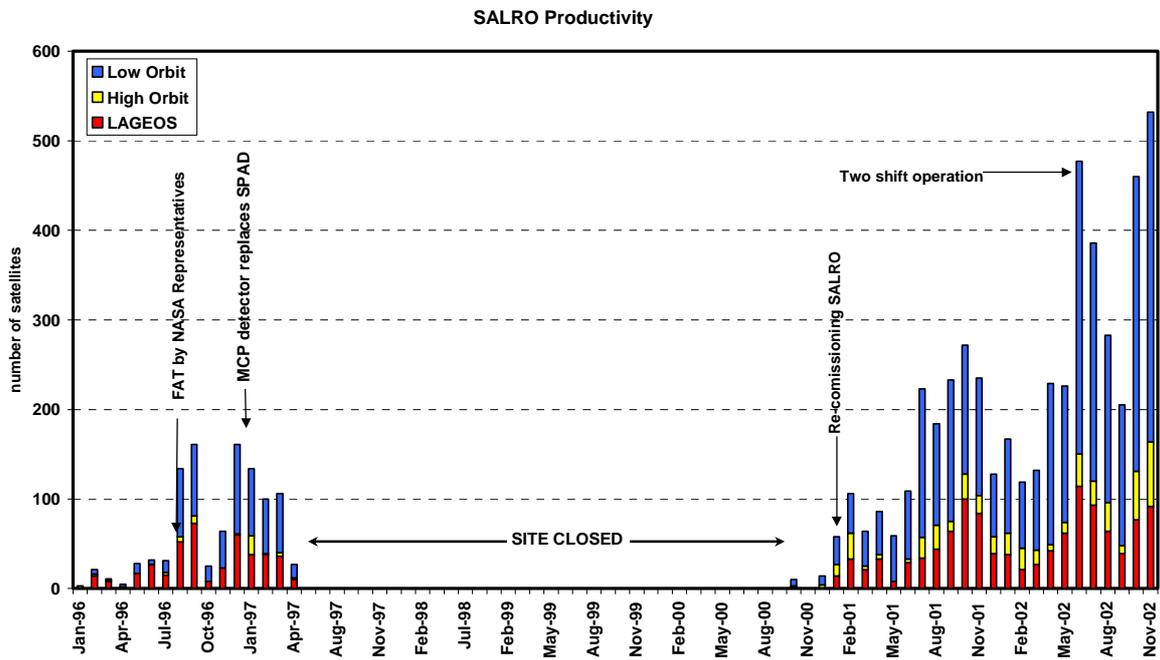


Figure 2: Monthly SALRO Productivity from 1996 to 2002

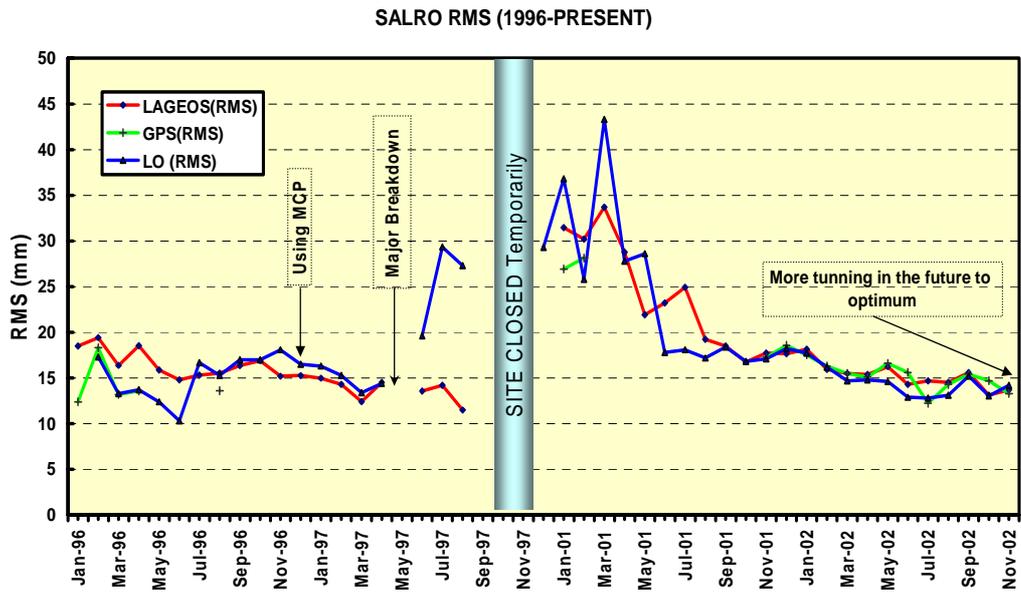


Figure 3: SALRO RMS from 1996 to 2002

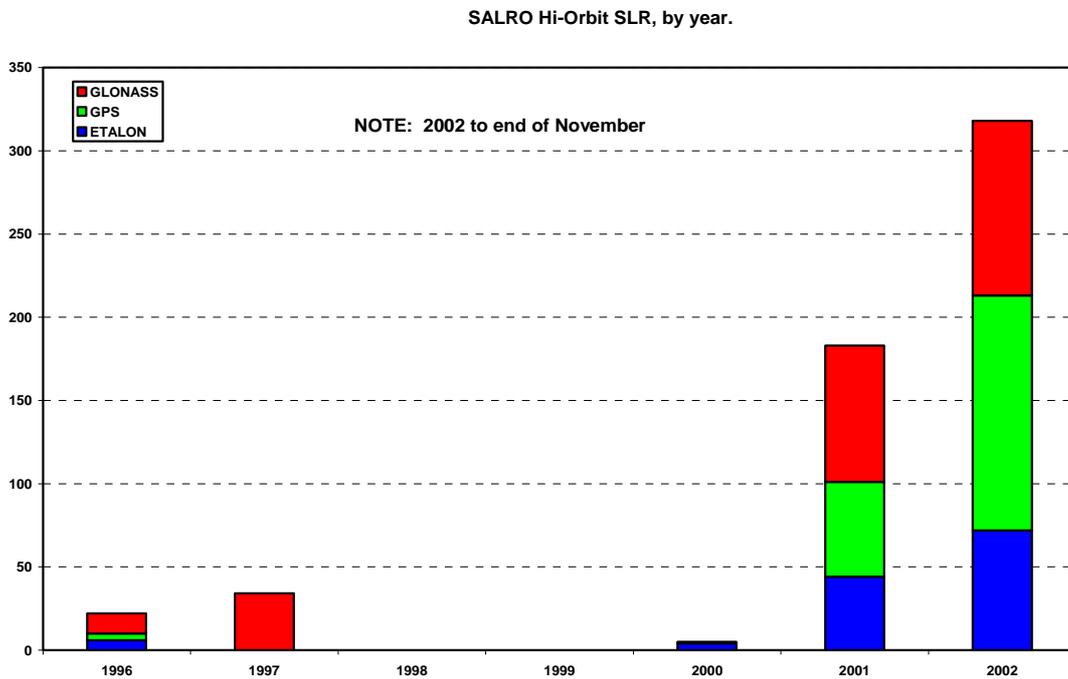


Figure 4: Number of passes for high orbit satellites from 1996 to 2002.

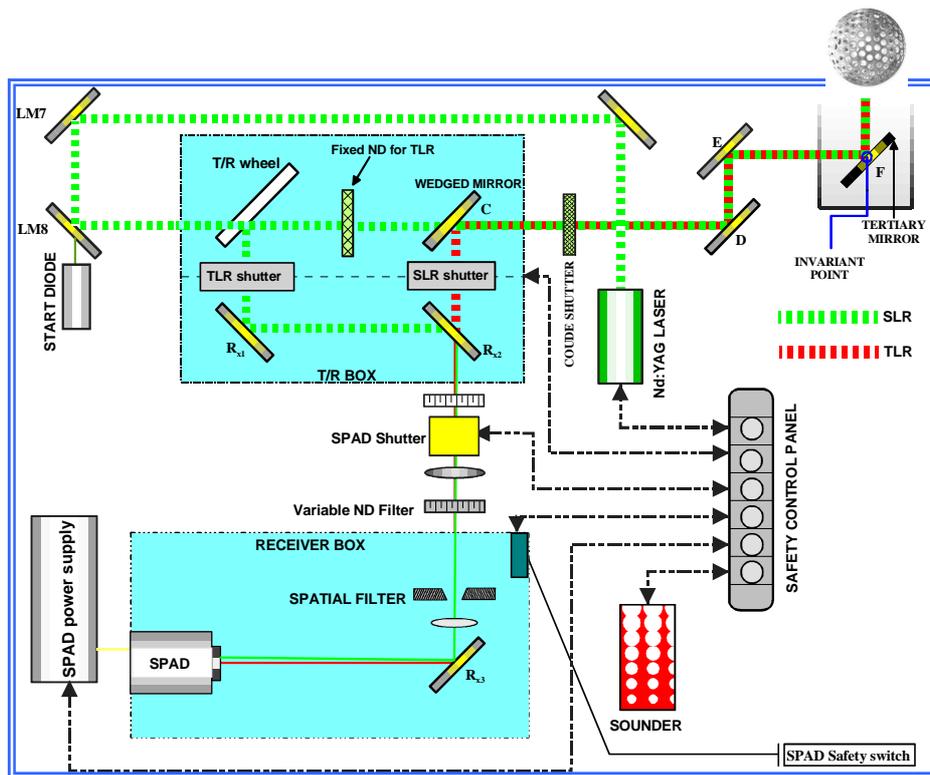


Figure 5: Schematic diagram of safety system.

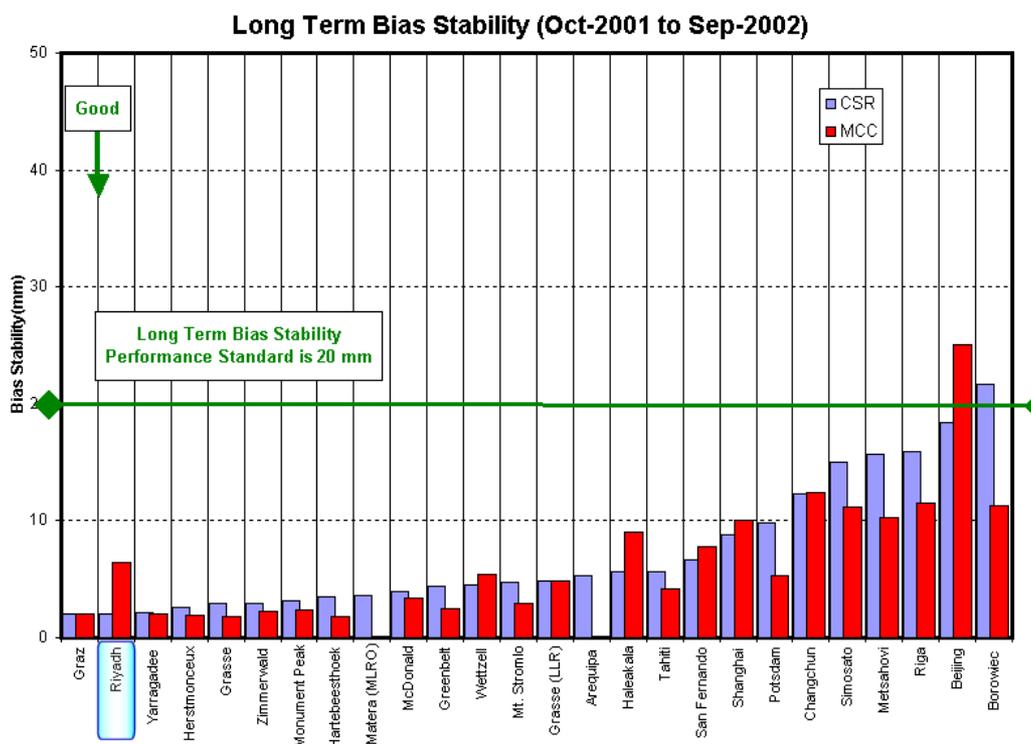


Figure 6: Long Term Bias Stability Performance of SLR stations.

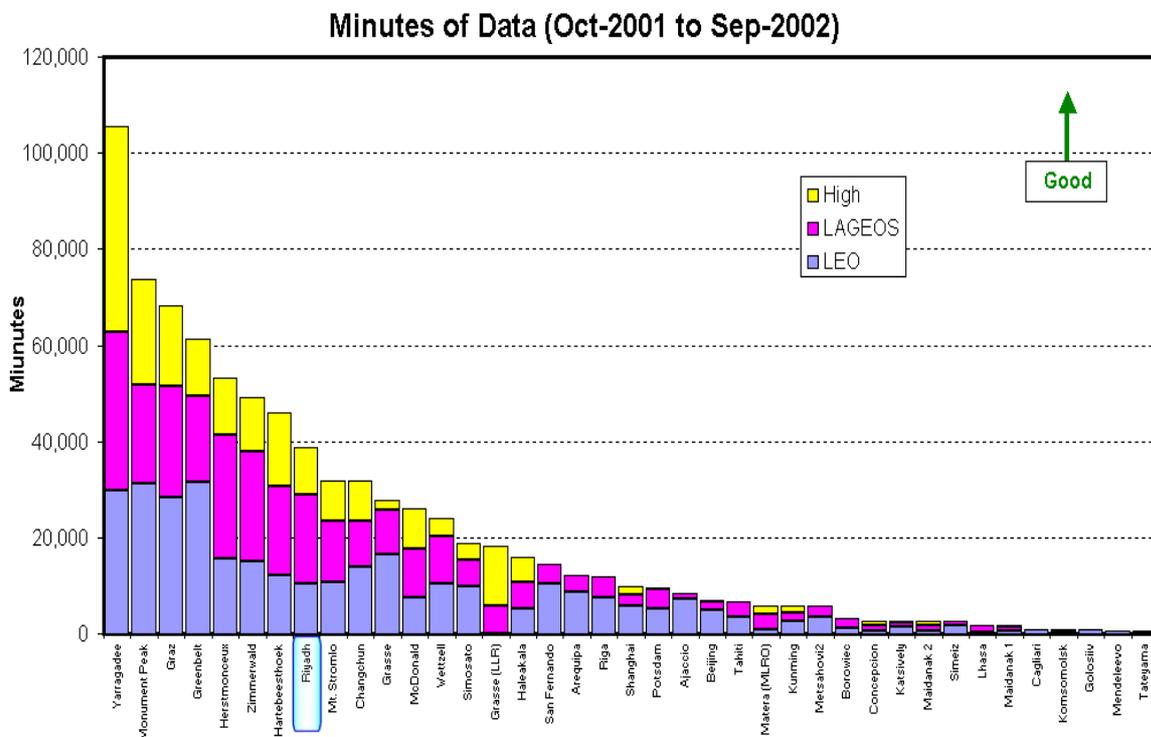
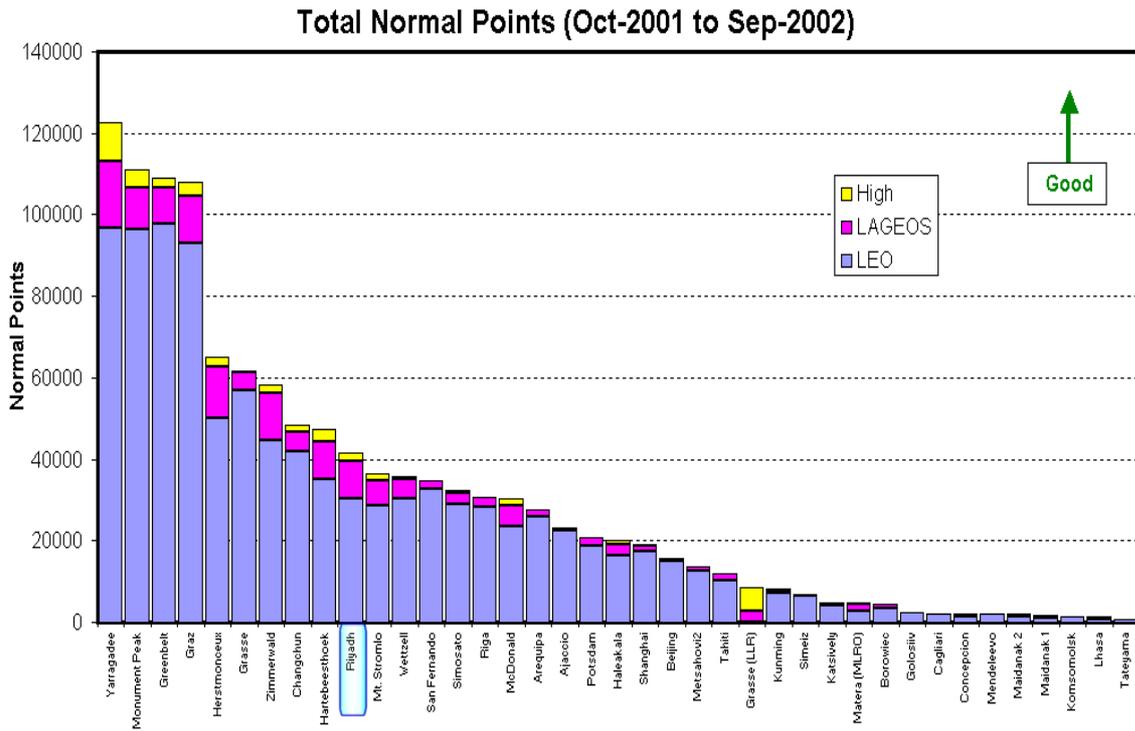


Figure 7: Normal point and Minutes of data performance of SLR Stations.